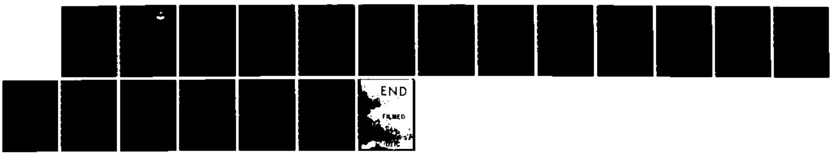
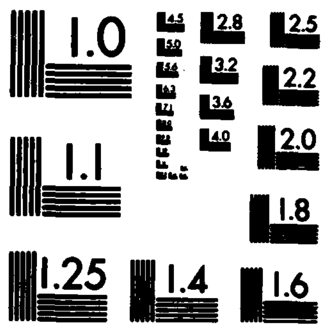
AD-A145 655 BASELINE WASTE ANESTHETIC GAS SURVEY DAVID GRANT MEDICAL CENTER SURGICAL..(U) AIR FORCE OCCUPATIONAL AND ENVIRONMENTAL HEALTH LAB BROOKS AF.. J E BOHNE AUG 84 1/1

UNCLASSIFIED OEHL-84-300EH190HGA F/G 6/15 NL





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USAF OEHL REPORT
84-300EH190HGA

FOR HEALTH & ENVIRONMENT

AD-A145 655

BASELINE WASTE ANESTHETIC GAS SURVEY
DAVID GRANT MEDICAL CENTER SURGICAL SUITE
TRAVIS AFB CA

USAF Occupational and Environmental Health Laboratory
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235

84 09 14 026

NOTICES

JOHN J. COUGHLIN, Colonel, USAF, BSC
Commander

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION
Unclassified

1b. RESTRICTIVE MARKINGS
None

2a. SECURITY CLASSIFICATION AUTHORITY

3. DISTRIBUTION/AVAILABILITY OF REPORT
Unlimited, approved for public release

2b. DECLASSIFICATION/DOWNGRADING SCHEDULE

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
84-300EH190HGA

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION
USAF Occupational and Environmental Health Laboratory

6b. OFFICE SYMBOL *(If applicable)*
ECH

7a. NAME OF MONITORING ORGANIZATION
David Grant USAF Medical Center
Travis AFB CA 94535

6c. ADDRESS *(City, State and ZIP Code)*
Brooks AFB TX 78235

7b. ADDRESS *(City, State and ZIP Code)*

8a. NAME OF FUNDING/SPONSORING ORGANIZATION
Same as 6a

8b. OFFICE SYMBOL *(If applicable)*

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS *(City, State and ZIP Code)*
Brooks AFB TX 78235

10. SOURCE OF FUNDING NOS.

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.

11. TITLE *(Include Security Classification)* (U) Baseline Waste Anes Gas Sur David Grant Med Cen Travis AFB CA

12. PERSONAL AUTHOR(S)
BOHNE, JAMES ELMAN, JR.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT *(Yr., Mo., Day)*	15. PAGE COUNT
Final	FROM 26 Jan TO 2 Feb 84	August 1984	16

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB. GR.

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
Travis AFB; halothane; baseline survey; DGMC; nitrous oxide; surgery; forane; forane; N_2O; anesthetics; anesthic gas

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

The current Air Force policy regarding waste anesthetic gases is to reduce exposure to operating personnel to a level as low as practical. To this end, the Air Force Surgeon General has mandated a control program which includes establishing baseline data and conducting semiannual routine surveys. Modifications in their gas delivery and scavenging systems required the David Grant USAF Medical Center to request a survey by the USAF Occupational and Environmental Health Laboratory to establish a new baseline. This report presents the results of the revised baseline.

[illegible] nitrous oxide, [illegible] halothane

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐

21. ABSTRACT SECURITY CLASSIFICATION
Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL
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22c. OFFICE SYMBOL
ECH

DD FORM 1473, 83 APR — EDITION OF 1 JAN 73 IS OBSOLETE.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

Report No. 84-300EH190HGA

USAF OCCUPATIONAL AND ENVIRONMENTAL

HEALTH LABORATORY

Brooks AFB, Texas 78235

Baseline Waste Anesthetic Gas Survey

David Grant Medical Center Surgical Suite

Travis AFB CA

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I. INTRODUCTION

The delivery of general anesthesia to a patient usually entails some leakage of the anesthetic gas into the operating room (OR). Air Force policy is to reduce personnel exposure to these anesthetic gases to as low as practical. A program mandated by the U.S. Air Force Surgeon General includes establishing baseline data to compare the results of subsequent semiannual surveys.[1]

A baseline survey of the David Grant USAF Medical Center (DGMC) operating rooms conducted by its Bioenvironmental Engineering staff (DGMC/SGPB) 8 Aug-10 Sep 82 indicated a need for some changes in the ventilation system.[2] The resulting modifications of the ventilation and scavenging systems necessitated the development of a new waste anesthetic gas baseline. Due to a shortage of manpower and equipment, the USAF DGMC/SGPB requested the USAF Occupational and Environmental Health Laboratory (USAF OEHL) perform the survey.[3] The survey was conducted 26 Jan-2 Feb 84 by the USAF OEHL Consultant Services Division, Industrial Hygiene Branch (USAF OEHL/ECH).

II. BACKGROUND

A. Air Force Policy

1. Although currently there is insufficient information on which to base an Air Force Occupational Safety and Health (AFOSH) Standard, the USAF Surgeon General's office has determined that there is sufficient concern to warrant efforts to reduce exposure to waste anesthetic gases to the lowest practical level. A HQ AFMSC/SGPA letter dated 14 Nov 80, subject "Control of Occupational Exposures to Anesthetic Gases" mandates a control program for USAF medical facilities consisting of the following elements:

a. Scavenging of waste anesthetic gases

b. Low leakage practices

c. Air monitoring

d. Equipment maintenance and leak testing

e. Worker education

2. Inquiries regarding this policy should be referred to Headquarters Air Force Medical Service Center, Bioenvironmental Engineering Division (HQ AFMSC/SGPA), Brooks AFB TX 78235 (AV 240-2452).

B. Health Effects of Anesthetic Gases

1. A 1977 criteria document published by the National Institute for Occupational Safety and Health (NIOSH) relates exposure to anesthetic gases with increased incidence of spontaneous abortions, congenital abnormalities and toxic effects on the liver, kidneys and central nervous system.[4] The

NIOSH document cites studies showing a moderate increase in the spontaneous abortion rates for operating room nurses, female anesthetists, nurse anesthetists and wives of exposed dentists.

2. A more recent review of the literature also concludes that there is reasonably convincing evidence of an increase in spontaneous abortion among exposed females. However, there is less agreement in the literature on increased risk of spontaneous abortions to wives of exposed husbands, or on the increased incidence of congenital malformation, liver and kidney disease or increased risk of cancer.[5] At levels considered to be well above occupational exposures, some anesthetic gases (chloroform, trichloroethylene, and isoflurane) have been demonstrated to have carcinogenic potential.[6] However, there is still some concern about carcinogenicity at occupational exposure levels since the urine of anesthesiologists has been found to be mutagenic.[5]

3. Effects of halothane on the central nervous system has been demonstrated in laboratory animals. Damage to cerebral cortical neurons has been demonstrated in adult rats and in the offspring of pregnant rats exposed to 8 to 12 ppm of halothane for 8 hours/day, 5 days/week from conception to 60 days of age.[4]

4. Very little is known about the biochemistry of anesthetic gases. Metabolic studies of halogenated agents are generally limited to analysis of metabolites found in exhaled air and in urine samples. Nitrous oxide is known to inactivate vitamin B-12, thereby preventing formation of pyrimidine bases needed for RNA and DNA synthysis.[7] Nitrous oxide has also been shown to inhibit cell division in human bone marrow cells.[8]

III. DISCUSSION

A. Materials and Methods

1. Two MIRAN infrared analyzers were connected in series to detect nitrous oxide and the halogenated agent in use. These monitors were used to scan the anesthesia delivery apparatus for leaks and to identify events which may lead to anesthetic gas exposure.

2. Nitrous oxide was also measured for the duration of the surgery with Nitrox[R] passive dosimeters. These samplers are produced, supplied by and analysed by R.S. Landauer, Jr., & Co., Glenwood IL.

3. Halogenated anesthetic gases were collected on charcoal tubes at airflows measured before and after the sampling period with calibrated DuPont P-200 calibration kits. The samples were analysed at the USAF OEHL Analytical Services Division (SA), Brooks AFB TX.

4. Nitrox and charcoal tube samplers were placed at exhaust grilles in the operating rooms or as in the previous survey by DGMC/SGPA (lower exhaust grille in room 5). In operating rooms 3 and 4 an additional sampling point was monitored at the lower grille located on each sterilizer room door

(see Figures 1-5, Appendix A). The sterilizer rooms were under negative air pressure compared to the operating rooms, so the door grilles were a logical point through which OR air would flow. See Table I for a summary of airflows through exhaust grilles. Only 28% and 18% of supply air passed through the exhaust grills in rooms 3 and 4 respectively. Additional sampling points were established in rooms 3 and 4 at the door grilles since less than half the supply air was passing out the exhaust for those rooms. The supply air passing through the exhaust grilles of the remaining ORs was 51-69%.

Table I

Ventilation Rates in Operating Rooms[9]

OR No.	Supply Air (cfm)	Exhaust Air (cfm)	Exhaust/ Supply Air	Air Changes/Hour (Supply/Room Volume)
1	718.9	364.65	0.51	19.1
2	891	516.2	0.58	25.4
3	1078	298.6	0.28	22.4
4	1462	260.6	0.18	29.0
5	1361.1	937.6	0.69	17.5

B. Results

1. The specific type of operations which were surveyed for the baseline are listed in Table II. The surgical procedures designated as 1D (removal of NLD obstruction, placement of crawford tubes) and 1E (Dacryochystorhinostomy) were pedodontal procedures using a mask to deliver anesthesia during the operation. All other procedures used intubation following initial sedation with a mask. Table III presents the air concentrations measured during the operations listed in Table II and summarizes the results in terms of an arithmetic mean value for each sampling location in each room. These averages are the baseline values to which the results of future routine surveys should be compared.

2. According to the Air Force policy letter on waste anesthetic gas[10], a concentration of two times the baseline value requires action to identify and correct the source of anesthetic gas. The policy states that the baseline shall be continually revised by taking the mean of the four most recent sample results.[11]

Table II

Operations Surveyed

Room No.	Test No.	Type Procedures	Duration (min)	Date
1	A	Mandibular Stabilization, Explor Facial Fracture	378	30 Jan 84
1	B	Appendectomy	135	30 Jan 84
1	C	Retroperitoneal Node Dissection	318	31 Jan 84
1	D	Removal of NLD Obstruction, Placement of Crawford Tubes	51	1 Feb 84
1	E	Dacryochystorhinostomy	154	1 Feb 84
1	F	Reduction of Facial Fracture	592	2 Feb 84
2	A	D&C	32	27 Jan 84
2	B	Laparoscopy, Tubal Ligation	102	27 Jan 84
2	C	Abdominal Hysterectomy, Bilat Salpingo Oophorectomy, Poss Omentectomy	184	30 Jan 84
2	D	Total Abd Hysterectomy, Bilat Salpingo-Oahorectomy	403	30 Jan 84
2	E	Panendoscopy, Lt Neck Aspirate, Biopsy	57	31 Jan 84
2	F	Panendoscopy	54	31 Jan 84
2	G	Panendoscopy	35	31 Jan 84
3	A	Splenectomy, Staging Laparotomy	154	27 Jan 84
3	B	Rt Thyroid Lobectomy, Poss Subtotal Thyroidectomy	178	30 Jan 84
3	C	Cholecystectomy, Poss Interoperative Cholangiogram	206	30 Jan 84
3	D	Laparoscopy, Poss Laparotomy,Tubal Reanstamosis	62	31 Jan 84
3	E	Emergency Hemorrhage	195	31 Jan 84
3	F	Bilateral Orahidopexy	72	2 Feb 84
4	A	Lt Open Lung Bx	71	27 Jan 84
4	B	Rt Hemicolectomy	138	27 Jan 84
4	C	Gallbladder	98	27 Jan 84
4	D	Removal of Staple, Lt Tibia	120	30 Jan 84
4	E	Incisional Herniorrhaphy	84	30 Jan 84
5	A	Gallbladder	86	26 Jan 84
5	B	Decompressive Lami	261	27 Jan 84
5	C	Staple Removal	52	30 Jan 84
5	D	ORIF Rt Femur	265	30 Jan 84
5	E	ORIF Lt Patella	127	30 Jan 84
5	F	Lumbas Hemilaminectomy	73	31 Jan 84

Table III

Survey Results: Anesthetic Gas Concentrations

Room Test No.	Halogenated Gas	Concentration (ppm) Exhaust Grille Halogenated Gas	Exhaust Grille N_2O	Lower Door Grille Halogenated Gas	Lower Door Grille N_2O
1A	Forane	0.244	17		
1B	Forane	ND(<0.029)	31		
1C	Forane	0.137	17		
1D	Halothane	1.94	115		
1E	Halothane	1.29	45		
1F	Forane	0.134	9		
AVERAGE		0.629	39.0		
2A	*	——	421		
2B	Forane	6.30	343		
2C	Forane	1.55	150		
2D	Forane	1.99	157		
2E	*	——	153		
2F	Forane	2.97	98		
2G	Forane	3.41	150		
AVERAGE		3.24	210		
3A	Forane	0.414	59	0.371	33
3B	Forane	0.332	77	0.086	65
3C	Forane	0.268	40	0.858	53
3D	*	——	127	——	92
3E	Forane	ND (<0.021)	30	ND (<0.020)	29
3F	Forane	1.17	50	1.19	58
AVERAGE		0.442	63.8	0.505	55
4A	Halothane	0.118	30	ND (<0.050)	48
4B	Forane	ND (<0.025)	9	ND (<0.026)	66
4C	Forane	ND (<0.040)	7	ND (<0.038)	23
4D	Forane	0.153	15	0.163	17
4E	Forane	0.224	34	0.276	33
AVERAGE		0.112	19	0.111	37
5A	Forane	ND (<0.047)	78		
5B	Forane	0.859	81		
5C	Forane	1.43	60		
5D	Forane	0.386	22		
5E	Forane	0.638	46		
5F	Forane	0.162	41		
AVERAGE		0.587	55		

*Nitrous oxide was the only anesthetic gas used.

3. Sample sites in this baseline study were selected to be representative of the anesthetic concentrations in the general room air and to be easily identifiable locations for future baseline comparison studies. Nitrox dosimeters were used to evaluate baseline concentrations while MIRAN IR equipment was used to spot check leaks and evaluate anesthetic technique. Nitrox dosimeters have been shown to produce results equivalent to the MIRAN IR spectrophotometer.[13] Table IV presents a summary of the Nitrox data obtained during this survey and the results of the 1982 baseline study. Strict comparisons of the nitrous oxide data are not warranted since sampling locations were not identical. The baseline values for OR 2 are notably higher than the other ORs in the 1984 survey, and also higher than the 1982 value for that room. These results have been noted and reported to DGMC personnel for their investigation.

Table IV

Comparison of Baseline Values (ppm)

Operating	Nitrous Oxide		Halogenated Gases	
Room	1982 Survey*	1984 Survey	1982 Survey	1984 Survey
1	154.0	39	1.09	0.629
2	94.3	210	1.76	3.24
3	55.6	63.8	2.22	0.442
4	41.0	19	0.42	0.112
5	81.8	55	0.46	0.587

*These concentrations determined by MIRAN IR analyser

IV. CONCLUSIONS

1. With the exception of OR 2, the results suggest the alterations made in the anesthesia delivery and scavenging systems, since the 1982 survey, have effectively reduced anesthetic gas leakage.

2. Both nitrous oxide and halogenated gas levels are elevated in OR 2 compared to the other rooms surveyed. Some leakage of nitrous oxide was noted during the survey; however, since no leakage of halogenated gases was detected with the MIRAN on the gas delivery lines, the elevated levels are most likely due to leakage from the mask or patient when intubated. This could be a result of low airflows in the scavenging system due to insufficient vacuum or poor mixing of make-up air in the room's ventilation system. Leakage in the scavenging system would not be detected by the MIRAN since that part of the system is under negative pressure. A leak would result in room air being drawn into the scavenging hose rather than an expulsion of the anesthetic mixture. From Table I, the air exchange rate in OR 2 is similar to that in the other OR's, however, there is a potential for "short circuit" of the make-up air given the close proximity of the feed and return plenums. Poor mixing of the make-up air could cause elevated anesthetic concentration.

V. RECOMMENDATIONS

1. The Landauer Nitrox passive monitors are an efficient, less bulky and intrusive, alternative to the MIRAN IR analyser for measuring nitrous oxide concentrations during baseline and routine surveys. The USAF OEHL/ECH recommends continued use of these samplers for baseline comparison at the same sampling locations used in this survey.

2. The anesthetic gas delivery and scavenging systems in OR 2 should be inspected by DGMC/SGLB with special attention given to the scavenging system with regard to airflow, leakage, and properly operating valves. The base BEE should evaluate mixing of air in OR 2 using ventilation survey methods to determine the "short circuit" potential. If engineering or maintenance modifications are implemented, a new baseline will need to be developed for OR 2.

References

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3. USAF DGMC/SGPB letter, 25 Oct 83, Request for OEHL Field Support Survey-Waste Anesthetic Gases.

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5. Edling, C., "Anesthetic Gases as an Occupational Hazard: A Review," Scand. J. Work Environ. Health, 6(2):85-93 980).

6. Corbett, T.H., "Cancer and Congenital Anomalies Associated with Anesthetics," Ann. NY Acad. Sci., 271:58-66 (1976).

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8. Cullen, M.H.; G.M. Rees; D.G. Nancekievill; J.A.L. Amess, "The Effect of Nitrous Oxide on the Cell Cycle in Human Bone Marrow, "Br. J. Haematol 42(4):527-534 (1979).

9. Adapted from USAF DGMC/SGPB ventilation surveys, 22 Nov, 15 Dec and 20 Dec 83.

10. HQ AFMSC/SGPA letter, 14 Nov 80, Control of Exposures to Anesthetic Gases, (Atch 1).

11. Ibid, Appendix D.

12. Hossain, Mohammad A. and Edward C. Bishop, "Field Evaluation of Passive Monitors for Waste Anesthetic Gases," USAF OEHL Report No. 82-4, May 82.

APPENDIX A

Figure 1

Operation Room #1

Figure 2

Operation Room #2

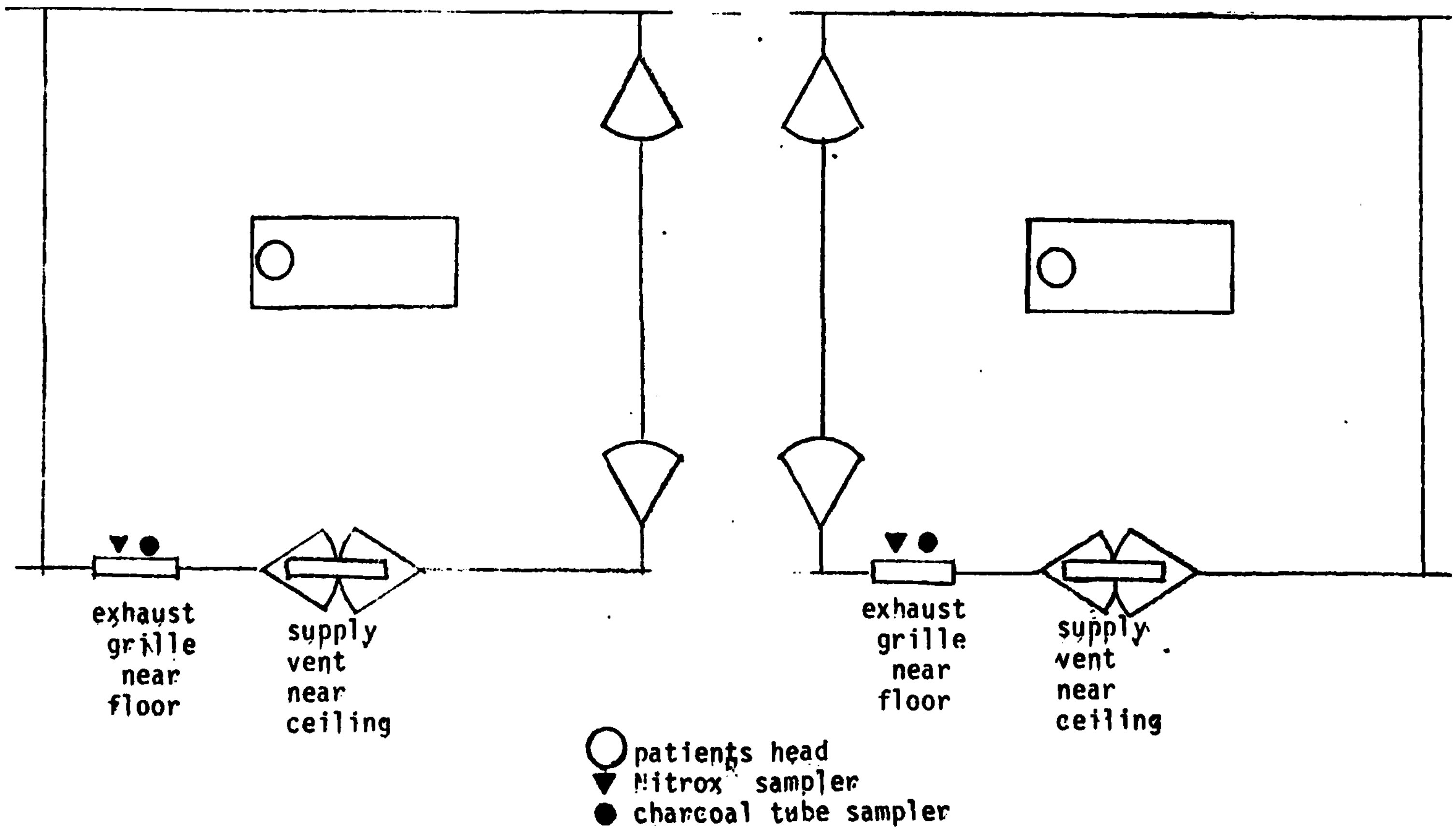


Figure 3

Operating Room #3

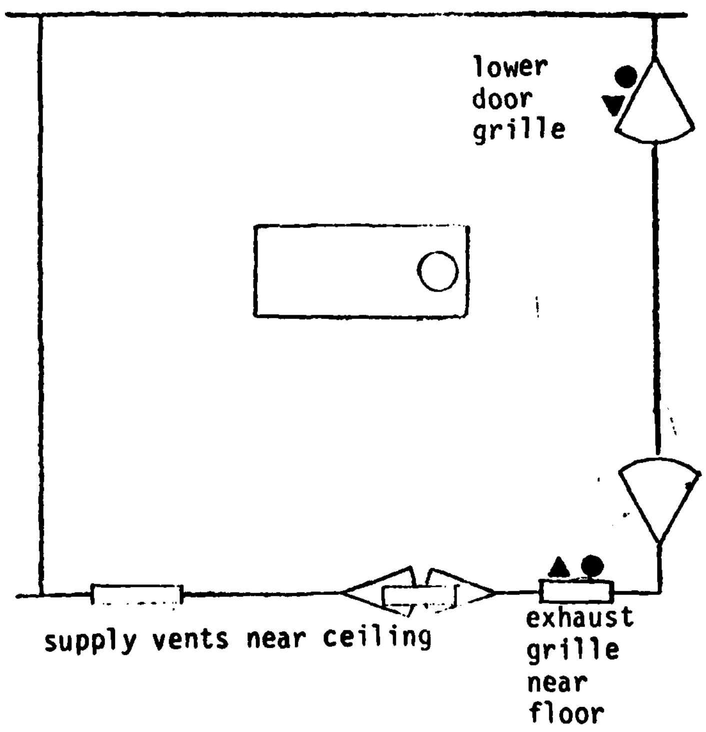
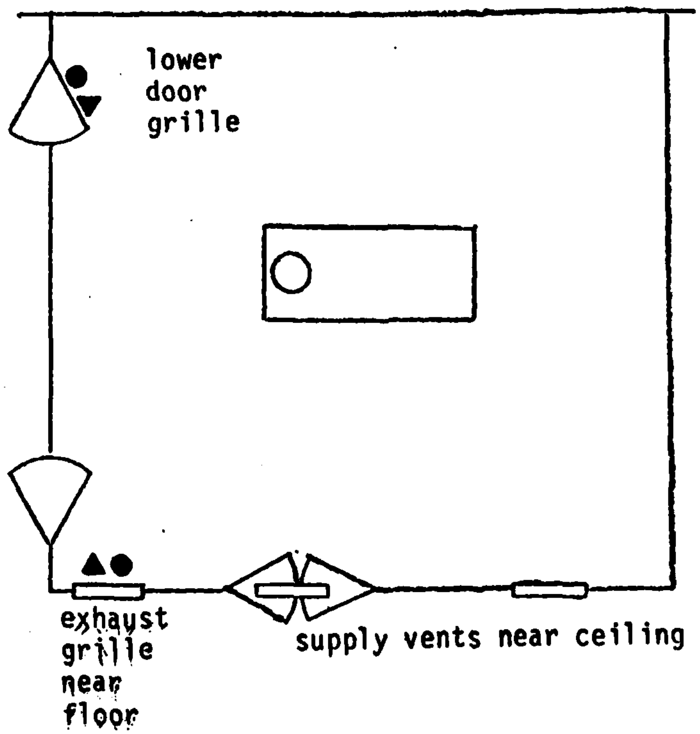


Figure 4

Operating Room #4



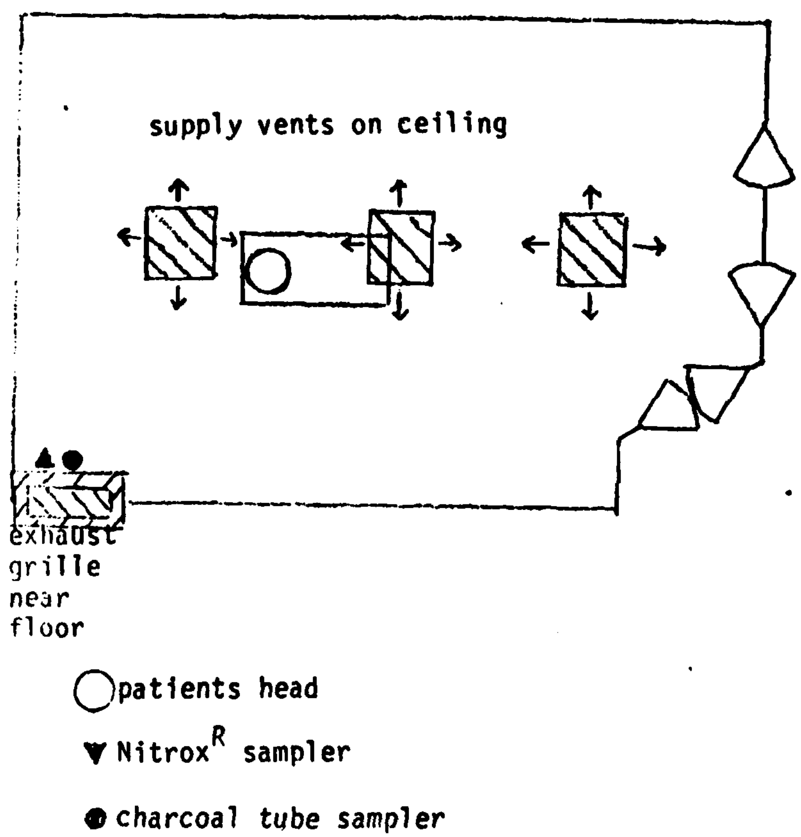
patients head

Nitrox[R] sampler

charcoal tube sampler

Figure 5

Operating Room #5



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